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# RADIONUCLIDE EVALUATION IN SEDIMENT SAMPLES IN SOME COMMUNITIES IN EDO STATE, NIGERIA.

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## ABSTRACT

*This study evaluates radionuclide levels in sediment samples from some communities in Edo State, Nigeria. Twelve sediment samples were collected from four communities at a depth of 10 cm, with each site providing 200 g of samples spaced 50 m apart and these were analysed using Gamma Ray Spectrometry (NaI(Tl) detector) to measure the activity concentrations of $^{238}U$, $^{232}Th$,and $^{40}K$. The results revealed that activity concentrations in sediment samples for $^{40}K$, $^{238}U$, and $^{232}Th$ ranged from 112.94±3.54 to 613.97±8.25, 3.49±0.05 to 18.47±0.13, and 1.12±0.05 to 8.65±0.13 Bq/kg, respectively.. The variations may stem from geological differences and the presence of radioactive thorium minerals. Although radionuclide hazard indices indicate the communities are safe from radiation, the long-term effects of low-dose radiation exposure could pose health risks, and regular monitoring of radionuclide levels in sediments is recommended for Edo State.*

***Keywords: Radionuclides, Sediment, Communities, Health, Risk, Radiation.***

## INTRODUCTION

Evaluating radioactivity in soil and sediments is vital for preserving human health and minimizing adverse effects [1 – 3]. Radioactive nuclides in the environment stem from numerous sources, including natural ones like weathered rock and artificial ones from human activities such as mining, fertilizers, and medical facilities. Three naturally abundant radionuclides, $^{238}U$, $^{232}Th$, and $^{40}K$, can enter water bodies, indirectly make their way into the food chain [4 – 6], and ultimately accumulate in the human body through seafood. The negligent disposal radioactive sourcesand untreated industrial effluents poses significant risks to human health. Significant radiation doses to people might possibly arise after radioactive poisoning of water bodies including rivers, lakes, and reservoirs. Radionuclides may be transported from soil to plants, animals, and eventually exposed to people [3, 8 – 9]. These radionuclides may emerge as hazardous components and undergo bioaccumulation and bio concentration, resulting in detrimental effects on individuals and their surroundings [10]. Evaluating the level of contaminated sediments through the activities of aquatic lives and its related health hazards to users in various study areas becomes necessary. The objective of this study is to evaluate the health risks associated with natural radioactivity concentration in sediment in selected coastal areas in Edo State Nigeria.

## MATERIALS AND METHOD

### Materials

The research materials used in this research are the sediment samples, thermometers, $H_2SO_4$ , Gamma Ray Spectrometry (NaI(Tl) detector), vials containers and computer.

### Study Area

The study area is underlain by sedimentary rocks and is found within Benin, Bende-Ameki, Ogwashi-Asaba, Nmo and nsukka formations [13]. The studied locations in Edo State with their coordinates are shown in Table 1.

**Table 1: Description of sediment samples collected from Edo State**

| Locations | Geographical Coordinates | Sample codes | Description of Sample codes |
|---|---|---|---|
| Ogba 1 | Long. 5.5821705<br>Lat. 6.2849025 | OBSD1ED | Ogba Sediment 1 Edo |
| Ogba 2 | Long. 5.5823069<br>Lat. 6.2847544 | OBSD2ED | Ogba Sediment 2 Edo |
| Ogba 3 | Long. 5.5824967<br>Lat. 6.2851333 | OBSD3ED | Ogba Sediment 3 Edo |
| Uvbua 1 | Long. 5.7581783<br>Lat. 6.2027650 | UVSD1ED | Evbuarhue Sediment 1 Edo |
| Uvbua 2 | Long. 5.7596968<br>Lat. 6.2021195 | UVSD2ED | Evbuarhue Sediment 2 Edo |
| Uvbua 3 | Long. 5.7599500<br>Lat. 6.2023653 | UVSD3ED | Evbuarhue Sediment 3 Edo |
| Gelegele 1 | Long. 5.3447443<br>Lat. 6.1555097 | GESD1ED | Gelegele Sediment 1 Edo |
| Gelegele 2 | Long. 5.3454862<br>Lat. 6.1561306 | GESD2ED | Gelegele Sediment 2 Edo |
| Gelegele 3 | Long. 5.3483275<br>Lat. 6.1609400 | GESD3ED | Gelegele Sediment 1 Edo |
| Ologbo 1 | Long. 5.6631734<br>Lat. 6.0533387 | OLSD1ED | Ologbo Sediment 1 Edo |
| Ologbo 2 | Long. 5.6625925<br>Lat. 6.0531807 | OLSD2ED | Ologbo Sediment 2 Edo |
| Ologbo 3 | Long. 5.6640505<br>Lat. 6.0525589 | OLSD3ED | Ologbo Sediment 3 Edo |

## Method

Twelve (12) sediment samples were randomly collected from Four communities within the study area at a depth of 10 cm, gathering 200g of samples at each designated site, spaced 50 m apart. These locations, marked with their geophysical coordinates, were selected based on community access to river water for uses, as detailed in Table 1. The samples of sediment were air-dried at 29 °C for a week [11 – 12], and crushed, ground to 1 mm, and oven-dried at 105 °C until reaching a consistent weight of about 200g is reached, The 200g were subsequently packed in cylindrical vials of uniform geometry which before now were soaked and washed with $H_2SO_4$ acid and raised with de-Ionized water to avoid contamination. The vials containers labeled sealed and sent to the laboratory for gamma counting analysis.

## Estimation of Radiological Parameters

### Absorbed Dose Rate (D)

The absorbed dose rate in the air from $^{40}$K, $^{238}$U, and $^{232}$Th (Bq/kg-1), were estimated using eqn (1).

$$D(nGyh^{-1}) = 0.462B_U + 0.604B_{Th} + 0.041B_K$$ (1)[3, 9, 14 – 17]

Accordingly, we adopted the same formalism used by [15, 18] to evaluate the Annual effective dose for external exposures (AED), the Radium Equivalent Activity Index ($Ra_{eq}$) were evaluated follwing the procedure adopted from [14, 18], while the Excess Lifetime Cancer Risk (ELCR) were estimated using[15, 19] formalism.

### External Hazard Index ($H_{ext}$)

The external hazard index serves as a valuable metric for regulating safety standards and protecting against gamma radiation emitted by various radioactive substances. was calculated using Equation (2), as referenced by [15, 20 – 21].

$$H_{ext} = \frac{B_K}{4810} + \frac{B_U}{370} + \frac{B_{Th}}{259} \quad (2)$$

Where $B_U$,$B_{Th}$ and $B_K$ represents $^{238}$U, $^{232}$Th and $^{40}$K respectively.

### Internal Hazard Index ($H_{in}$)

The internal hazard index, which quantifies exposure to radon and its progeny, is defined by Equation (3) [15, 20, 21].

$$H \; = \frac{B_K}{4810} + \frac{B_U}{184} + \frac{B_{Th}}{259} \quad (3)$$

Where $B_U$,$B_{Th}$ and $B_K$ represents $^{238}$U, $^{232}$Th and $^{40}$K respectively

### Gamma Index ($I_\gamma$)

The gamma index estimates the level of gamma radioactivity linked to various concentrations of specific radionuclides [21].

$$I_\gamma = \frac{B_K}{3000} + \frac{B_U}{300} + \frac{B_{Th}}{200} \quad (4)\ [22]$$

### Life Time Cancer Risk

This was estimated and defined by the equation below [23]. Cancer risk coefficient for Environmental exposure to Radionuclides by USEPA, 1999 is given in equation (5)

$$LCR = AC \times CR \times LS \times \text{AC} \quad (5)$$

Where AC is activity concentration of radionuclides; CR is the average consumption rate of examined food crops; LS = average life expectancy (56.05 years [24]) and RC is the radionuclides cancer mobility risk coefficient.

## RESULTS AND DISCUSSIONS

Tables 2 display the activity concentration of Edo State radionuclides sediments. The analysis of the radiological hazard indices for sediment samples from Edo is presented in Tables 3, Figures 2 depict the variation in radiological hazard indices of the sediments collected in Edo State.

**Table 2 : Activity Concentration of Radionuclide in sediments from Edo States**

| Sample codes | $^{40}$K (Bq/kg) | $^{238}$ U(Bq/kg) | $^{232}$Th(Bq/kg) |
|---|---|---|---|
| UVSD2ED | 309.54±5.86 | 8.98±0.1 | 5.59±0.12 |
| UVSD3ED | 360.46±6.32 | 8.94±0.1 | 5.44±0.13 |
| GEED1ED | 339.49±6.14 | 8.77±0.09 | 4.52±0.09 |
| GESD2ED | 386.09±6.54 | 4.38±0.09 | 4.02±0.09 |
| OBSD1ED | 241.08±5.17 | 9.63±0.09 | 3.77±0.09 |
| OBSD3ED | 231.21±5.06 | 8.08±0.08 | 3.12±0.08 |
| GESD3ED | 483.28±7.32 | 18.47±0.13 | 8.65±0.13 |
| OBSD2ED | 576.47±8.0 | 6.90±0.06 | 1.73±0.06 |
| OLSD1ED | 442.01±7.0 | 10.61±0.09 | 4.33±0.09 |
| OLSD2ED | 296.34±5.73 | 5.27±0.07 | 2.40±0.07 |
| OLSD3ED | 112.94±3.54 | 3.49±0.05 | 1.12±0.05 |
| UVSD1ED | 613.97±8.25 | 9.06±0.06 | 1.64±0.06 |
| **Mean** | **309.57±5.26** | **7.50±0.08** | **3.86±0.08** |
| **RL** | **420** | **33** | **45** |

**Table 3: Radiological hazard indices for sediment samples collected from Edo State**

| Samples | ADR ($nGyhr^{-1}$) | AEDE ($mSvyr^{-1}$) | ELCR x $10^{-3}$ | $H_{in}$ | $H_{ex}$ | Req ($Bqkg^{-1}$) | AGED | Iγ |
|---|---|---|---|---|---|---|---|---|
| UVSD2ED | 22.56 | 0.1384 | 0.0790 | 0.1344 | 0.1120 | 255.32 | 148.31 | 0.3221 |
| UVSD3ED | 24.89 | 0.1526 | 0.0871 | 0.1443 | 0.1219 | 294.27 | 163.55 | 0.3543 |
| GESD1ED | 23.20 | 0.1423 | 0.0812 | 0.1354 | 0.1132 | 276.64 | 152.59 | 0.3230 |
| GESD2ED | 23.15 | 0.1419 | 0.0810 | 0.1197 | 0.1089 | 307.42 | 151.57 | 0.3268 |
| OBSD1ED | 18.36 | 0.1126 | 0.0643 | 0.1167 | 0.0919 | 200.65 | 121.21 | 0.2626 |
| OBSD3ED | 16.77 | 0.1028 | 0.0587 | 0.1038 | 0.0830 | 190.57 | 110.61 | 0.2392 |
| GESD3ED | 37.16 | 0.2279 | 0.1301 | 0.2337 | 0.1866 | 402.97 | 244.98 | 0.5318 |
| OBSD2ED | 31.89 | 0.1956 | 0.1116 | 0.1638 | 0.1457 | 453.26 | 209.56 | 0.4476 |
| OLSD1ED | 28.82 | 0.1767 | 0.1008 | 0.1660 | 0.1387 | 357.15 | 189.68 | 0.4087 |
| OLSD2ED | 18.16 | 0.1114 | 0.0636 | 0.0994 | 0.0859 | 236.88 | 119.37 | 0.2567 |
| OLSD3ED | 7.72 | 0.0473 | 0.0271 | 0.0467 | 0.0376 | 92.05 | 50.93 | 0.1098 |
| UVSD1ED | 34.60 | 0.2121 | 0.1211 | 0.1830 | 0.1590 | 484.16 | 227.64 | 0.4861 |
| Mean | 23.94 | 0.1468 | 0.0838 | 0.1372 | 0.1154 | 295.96 | 157.50 | 0.3396 |
| Standard value | 59 | 1 | 0.29 | 1 | 1 | 370 | 300 | 1 |

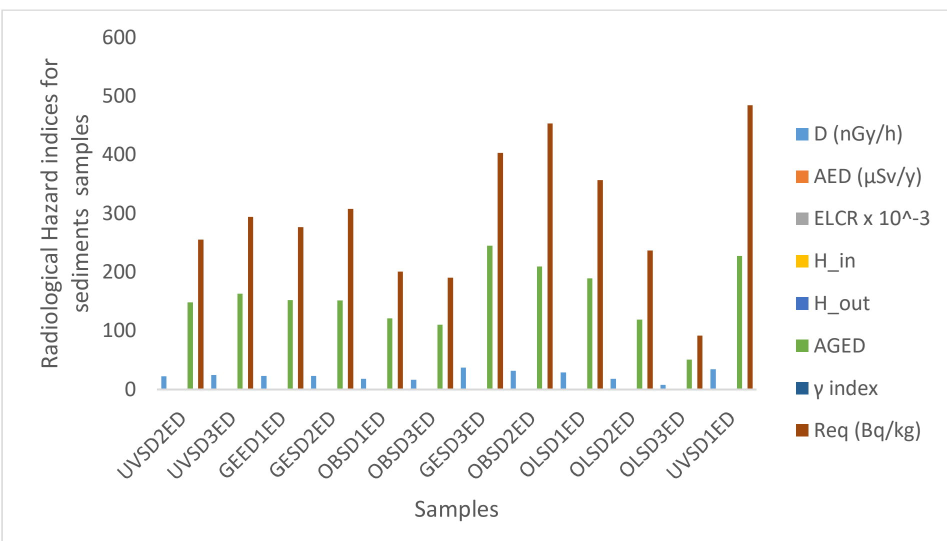


Figure 1: Variation of the Radiological Hazards for Sediments in the studied locations

The activity concentrations in sediment samples for $^{40}K$, $^{238}U$, and $^{232}Th$ varied from 112.94±3.54 to 613.97±8.25, 3.49±0.05 to 18.47±0.13, and 1.12±0.05 to 8.65±0.13, respectively, as shown in Table 2. The study indicated that the highest values for $^{40}K$, $^{238}U$, and $^{232}Th$ were 613.97±8.25, 18.47±0.13, and 8.65±0.13, found in samples UVSD1ED, GESD3ED and GESD3ED, respectively. The lowest values for $^{40}K$, $^{238}U$, and $^{232}Th$ were all detected in sample OLSD3ED. as presented in Table 4. These variations may be due to differences in geological structure and the presence of radioactive thorium minerals such as monazite, zircon, and thorite [25].

Tables 2, along with Figures 2 and 3, indicate the variations in the radiological hazard indices of sediment from the study area, respectively. The absorbed dose rate for sediment samples lies between 7.72 and 34.6 nGy/h, with an average value missing from the data provided. The lowest absorbed dose rate was recorded in sample OLSD3ED, and peaked at UVSD1ED. The estimated average absorbed dose rate is 23.94 nGy/h, approximately 42% lower than the global average of 59 nGy/h [26]. The reduced gamma dose rates in the absorbed doses may be attributed to the lower amounts of settled sling sediments on the water channels, forming bed sediments. The study reveals that the $H_{in}$ index are between 0.05 and 0.23, with 0.14 as mean. The peak value, 0.23, was recorded in GESD3ED, while the low-lying in OLSD3ED.

The $H_{out}$ index estimated for all samples lies inbetween 0.04 and 0.19, with an average of 0.12. The peak index, 0.19, was recorded in sample UVSD1ED, while the 0.04 was found in sample OLSD3ED. As indicated in Table 4, the $R_{eq}$ varies from 92.05 to 484.16 Bq/kg, with the peak and minimum values found in samples UVSD1ED and OLSD3ED, respectively. Comparing the mean value of 295.96 Bq/kg to the international standard of 370 Bq/kg, it falls within the acceptable limit [3, 14]. The gamma activity index measured varied between 0.11 and 0.53, with an average of 0.34. This average indicates that the dose rate in Edo State falls below the annual effective dose limit of 1 mSv/year. As a result, these sediments may be considered for exemption from regulations concerning radiological and radioactive risk..

The AGED values derived from this study for the sediment samples ranged between 50.93 and 244.98, corresponding to samples OLSD3ED and GESD3ED, respectively. The average value was determined to be 157.50, which is significantly below the permissible limit of 370 and considerably lower than the values. The mean value of 154.4601 obtained was well below the permissible limit of 370, aligning with findings [21, 27].

The reported AEDR values for sediment samples in this study range from 0.053 to 0.23 $\mu Svy^{-1}$, with the minimum and peak values recorded in samples UVSD1ED and GESD3ED. The mean value of 0.1468 is lower than the global average of 1 and the values[28]. Similarly, The study's findings on the Excess Lifetime Cancer Risk (ELCR) for sediment samples revealed that the lowest and highest values were $0.03\times10^{-3}$ and $0.13\times10^{-3}$, respectively, with an average of $0.08\times10^{-3}$. The minimum and maximum values corresponded to samples OLSD3ED and GESD3ED, respectively. The mean value reported in this study is lower than the global average of $0.29\times10^{-3}$, suggesting that the lifetime cancer risk for residents in the sampled areas is comparatively lower.

## CONCLUSION

The research carried out in some communities of Edo State evaluated the levels of radionuclides in sediments along with their radiological risk parameters. The calculated parameters are below globally recommended limits, suggesting a radiation-safe environment. While the current levels of radionuclide hazard indices do not present an immediate health risk, the cumulative effects of low-dose radiation exposure could lead to health issues over time. Consequently, it is advised that regular monitoring programs be established to track radionuclide levels in various environments, including sediment.

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